

## **AIRBAG MADE FROM LOW TENACITY YARNS**

### **Cross-Referenced to Related Applications**

This application is a divisional of pending U.S. Patent Application  
Serial Number 10/041,376, filed on January 8, 2002, which is hereby  
5 incorporated herein in its entirety by specific reference thereto.

### **Background of the Invention**

Airbag systems function by employing a sensor to detect a collision  
event, which triggers an inflator component to inflate the airbag cushion at  
10 high pressure. As a result of this process, the airbag cushion is subjected  
to a sudden and violent increase in gas pressure, which is then  
compounded by the impact of a vehicle occupant exerting external  
pressure against the airbag cushion. In order for the airbag cushion to  
protect occupants in a vehicle, it is necessary for the airbag to exhibit high  
15 burst strength.

Heretofore, various attempts have been made to manufacture an  
airbag cushion that is strong, robust, and exhibits high burst strength. One  
generally accepted method for manufacturing such cushions is by utilizing  
high tenacity multifilament yarns having tenacity of greater than 8.0  
20 grams/denier (g/den).

Japanese unexamined patent publication no. 4-5,145 teaches a  
non-circular airbag made from hollow weave fabrics having an axis length  
thereof in a direction at a bias angle of 45 degrees from the warp direction,

corresponding to 70 to 95% of the axis length thereof in the warp and weft direction.

Japanese unexamined patent publication no. 4-43,143 discloses an airbag made from non-circular hollow weave fabric pieces having a longer  
5 axis in a direction inclined at a bias angel from the warp or weft direction than an axis in the warp direction of the fabric pieces.

These attempts are based on the idea that a starting point in bursting of the airbag cushion resides in a seam-joining portion in a circumferential edge portion of the cushion, and provided a cushion made  
10 from non-circular woven fabric pieces having shorter axis in a bias direction than that in the warp or weft direction, to enhance the burst strength of the seam-joining portion.

U.S. Patent number 5,470,106 discloses the use of a woven fabric apron at the area surrounding the inflator connection to improve burst  
15 strength. Other attempts to improve burst strength have included the use of adhesive means to reinforce the weaker areas of the airbag. U.S. Patent number 5,296,278 teaches that bags having yarns with tensile strength measurements of less than 8.0 g/den (approximately 70 cN/tex or centi Newton/ tex) do not perform well. This reference also discloses a  
20 means for applying silicone rubber at the seams to prevent fraying of the coated fabric to prevent failure at the seams.

Most of the efforts to improve the burst strength of airbag cushions have been focused on using high tenacity yarns, occasionally in combination with some other means or method for increasing seam

strength. However, none of the prior art has provided an airbag cushion having a novel seam and low tenacity yarns in combination to provide high burst strength. One advantage to using low tenacity yarns in airbag cushion applications is that low tenacity yarns generally may be  
5 manufactured or purchased at a lower cost than high tenacity yarns.

### **Objects of the Invention**

Accordingly, it is an object of the present invention to provide an airbag cushion employing yarns having tenacity of less than 70 cN/tex  
10 while maintaining high burst strength.

Another object of the present invention is to provide an airbag cushion having a novel seam construction that allows an airbag cushion to be manufactured using low tenacity yarns without sacrificing acceptable levels of burst strength.

15 Still another object of the present invention is to provide a method for manufacturing an airbag cushion using yarns having tenacity of less than 70 cN/tex while maintaining high burst strength.

Yet another object of the present invention is to provide an airbag cushion that is inexpensive to manufacture, and which overcomes some of  
20 the problems commonly associated with other airbag cushions.

### **Brief Description of the Drawings**

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings where:

Figure 1A is a side view of a traditional seam structure utilized on airbag cushions;

Figure 1B is a cross-sectional view of the traditional seam structure shown in Figure 1A;

Figure 1C is a magnified cross-sectional view of the traditional seam structure shown in Figure 1B;

Figure 2A is a side view of an airbag cushion having a novel tri-stitch fold-over seam structure;

Figure 2B is a cross-sectional view illustrating the novel tri-stitch fold-over seam structure shown in Figure 2A;

Figure 2C is a magnified cross-sectional view of the novel tri-stitch fold-over seam structure shown in Figure 2B;

Figure 3A is a side view of an alternate embodiment of the airbag cushion shown in Figures 2A-2C, where the seam direction is reversed;

Figure 3B is a cross-sectional view illustrating the novel tri-stitch fold-over seam structure in the reverse direction;

Figure 3C is a magnified cross-sectional view illustrating the novel tri-stitch fold-over seam structure in the reverse direction;

Figure 4A is a side view of another embodiment of an airbag cushion having a novel tri-stitch fold-over seam, where the folded over portion of the seam is on the inner portion of the bag;

Figure 4B is a cross-sectional view illustrating the novel tri-stitch fold-over seam shown in Figure 4A;

Figure 4C is a magnified cross-sectional view illustrating the novel tri-stitch fold-over seam structure shown in Figure 4B;

Figure 5A is a side view of another embodiment of an airbag cushion having a novel double-stitch fold-over seam;

Figure 5B is a magnified cross-sectional view illustrating the novel double-stitch fold-over seam shown in Figure 5A;

Figure 5C is a magnified cross-sectional view illustrating the novel double stitch fold-over seam structure shown in Figure 5B.

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### **Description**

Airbag cushions typically comprise at least two fabric panels, each having a desired shape, sewn together to form a three-dimensional structure. Figures 1A-1C show a traditional double needle chain stitch seam structure 10 that has been commonly employed as a means for joining together fabric blanks that form airbag cushions. A first fabric blank 12 is joined to a second fabric blank 14 by means of an inner stitch 16 and an outer stitch 18. The double needle chain stitch structure has been used in the past because a single stitch did not provide enough seam strength,

and the burst strength of a bag employing such a seam structure suffered from unacceptably low burst strength.

One problem associated with the double needle chain stitch seam structure is that the high pressure caused by an airbag inflator causes the seam to tend toward peeling open (a condition referred to herein as the peel mode). Figure 1C shows the double needle chain stitch seam structure under stress in the peel mode. When the cushion expands due to the inflation pressure, the inner stitch receives the maximum stress, which sometimes results in the needle penetration holes formed by the inner stitch becoming susceptible to heat erosion from the hot inflation gases. The strength of the seams during the peel mode equals only about 60% to 70% of the strength of the fabric.

In order to improve the seam strength of the double needle chain stitch seam structure, thus increasing the burst strength of the airbag cushion, a third stitch 20 was added to the seam structure as shown in Figures 2A-2C. The third stitch 20 joins the first and second fabric blanks together, similarly to the inner stitch 16 and the outer stitch 18, but also joins the first fabric blank back onto itself in a folded manner as shown. Such an arrangement converts the stress condition on the seam structure from a peel mode to a shear mode, which spreads the stress load over multiple stitches within the seam, rather than having a single stitch bear the entire stress load. This seam arrangement, referred to herein as a tri-stitch fold-over seam (or tri-stitch), provides 100% of the fabric strength at the seams, and protects the inner 16 and outer stitches 18 against hot gas

erosion. Thus, the only possible gas leak area, between the inner 16 and outer stitches 18, is covered by a double layer of fabric.

Alternate embodiments are shown in Figures 3A-3C, where the second fabric panel is folded over onto itself, rather than the first fabric panel being folded over, as shown in Figures 2A-2C. Figures 4A-4C illustrate another alternate embodiment of the tri-stitch fold-over seam structure, where the second fabric panel is folded over onto itself, and where the folded portion is on the inside of the cushion rather than the outside of the airbag cushion. Figures 5A-5C illustrate an alternate embodiment of the novel seam structure, which is a double-stitch fold-over seam. In this embodiment, instead of applying two parallel seams to attach the fabric blanks prior to the fold-over step, the fabric blanks are attached using a single seam, and then the fabric seam is folded over and connected using a fold-over seam, as shown.

Using the tri-stitch fold-over seam or the double-stitch fold-over seam as described above allows airbag cushions to be manufactured with low tenacity yarns, where the use of such low tenacity yarns has not been possible in prior airbag cushion applications. Because the tri-stitch and double-stitch fold-over seams (collectively called "shear seams" herein) significantly strengthens the seam of the cushion, the necessity of using of high tenacity yarns in order to maintain acceptable burst strength levels for airbag cushions is obviated.

One preferred yarn is polyester. The preferred tenacity range is between about 60 cN/tex and about 35 cN/tex. A second preferred range

is about 50 cN/tex and about 40 cN/tex. The most preferred range is about 55 cN/tex and about 45 cN/tex. Although a specific yarn type has been disclosed, it is to be understood that any suitable yarn may be used.

The effectiveness of the seam as related to burst strength is

5 illustrated in the following examples:

**Example 1: Comparison of Low Tenacity vs. High Tenacity using  
Traditional Stitch**

A multifilament 620d polyester yarn of tenacity 5.1 g/den (45 cN/tex) was woven in the water-jet loom in a plain weave with a construction of 10 40x40 yarns per inch. This fabric was then calendared to achieve surface smoothness and coated with silicone rubber at a weight of 0.74 oz/sq. yd. A comparison of physical properties of this low tenacity fabric is shown in the following table along with a typical 630d nylon 6,6 silicone coated airbag fabric.

15 **Table 1: Physical Properties of Airbag Fabrics**

		<b>630d NY 6,6 Airbag Fabric</b>	<b>620d PET- Low Tenacity Fabric</b>
Yarn Tenacity	g/den.	9.3	5.1
Fabric construction, W/F	Per inch	41/40	40/40
Fabric total weight	Oz/sq. yd.	8.06	6.89
Coating Add-on	Oz/sq. yd.	1.1	0.74
Grab Tensile, W/F	Lbs/ inch	611/585	487/499
Elongation, W/F	%	35.1/37.1	38.4/35.2
Tongue Tear, W/F	Lbs.	50/55	42.5/53
Flammability	In/min	No Burn Rate	No Burn Rate
King Stiffness	Lbs	2.4	1.9
Fabric Modulus	Lbs/ inch	960	720



Tethered driver airbags of 52L volume was made from both of the above fabrics using the typical seaming techniques as shown in Fig. 1.

Two circular shaped panels were sewn along the perimeter with a double needle chain stitch. After the bags are turned inside out as shown, the perimeter seams are in the peel mode.

Airbag cushions manufactured using the above fabrics (one cushion made from high tenacity yarns, and one made from low tenacity yarns) employing traditional double needle chain stitch sewing techniques were tested with a 220-kPa-driver inflator statically and under loading. Nylon 6,6 bags performed well as expected, but the low tenacity polyester bags exhibited heat erosion at the perimeter seams resulting in considerable loss of pressure. Effective restraint functionality was lost in the low tenacity polyester bags because of the steep pressure decay ( $<1.0$  Psi at 45 msec). Even though the polyester fabric was coated, the uncoated side of the yarns gets exposed very easily to heat because of higher elongation at the seams with the low tenacity yarns. Also, with the heat capacity of Polyester being 1.5 kJ/kg. K compared to 1.7 kJ/kg. K for nylon, it is desirable to protect the uncoated side of the yarn at the seams and improve the seam overall.

#### **Example 2: Cushion Performance (High Tenacity vs. Low Tenacity) using Tri-Stitch**

The tri-stitch fold-over seam modification was implemented on sets of 52L driver bags made from silicone coated fabric woven with the low tenacity polyester yarns and high tenacity Nylon 6,6 yarns, respectively.

As before, these bags were tested statically and under load with the same 220 kPa driver inflator as before. Test results are summarized in the following Table 2.

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**Table 2. Bag Performance Parameters**

<b>BAG TYPE</b>	<b>Average Peak Bag Pressure (Psi)</b>
630d NY 6,6 with tri-stitch fold-over seam (Shear seam)	10.85
630d NY 6,6 traditional seam (Peel seam)	9.5
620d PET with tri-stitch fold-over seam (Shear seam)	11.9
620d PET traditional seam (Peel seam)	<1.0

Restraint functionality in terms of energy absorption for the new bag with low tenacity yarns was equivalent or better than traditional airbags made from high tenacity yarns. Visual inspection of the bags did not reveal any sign of heat erosion at the seams

### **Example 3: Drop Tests**

15 A set of airbag cushions were manufactured using 630d Nylon 6,6 at a construction of 41x41 yarns per inch for the control group, and fabric that was woven with low tenacity (4.8 g/den) polyester yarn of 620d at a construction of 40x40 yarns per inch was used to manufacture a second set of airbag cushions. Both the fabrics were woven on the waterjet loom and were silicone coated at a coating weight of 0.7 oz./sq. yd. All of the polyester cushions had the tri-stitch fold-over seam construction as shown in Figure 3. The inflator used for these tests was a 231 kPa inflator (in 60L

tank test) which is considered to be an aggressive inflator in the airbag industry.

Drop tests were conducted on the airbags by dropping a weight of 75 lbs. from a height of 6 feet onto the inflated bag. The 12 inch x 24 inch surface of the weight facing the bag was in the horizontal plane and the weight was constrained so it could move only up or down in the vertical direction. The peak deceleration rate as well as the peak-rebound height of the weight was recorded.

Table 3: Drop Test with Inflator (average of 6 bags each)

	Bag Pressure (Psi)	Peak G's	Rebound Distance (in)	Compression Distance (in)
630d Nylon 6,6 Airbag – traditional seam	10.2	20.8	27.5	5.84
620d Low Tenacity PET Airbag – tri stitch fold-over seam	11.4	16	<10	5.43

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The peak deceleration experienced by an object being brought to rest by an airbag is an important parameter in determining airbag performance. The peak deceleration measured in G's (multiples of the standard acceleration due to gravity) multiplied by the body weight gives the force exerted on the body to bring it to rest. Another important parameter is the amount of rebound experienced by an object after it is brought to rest. This parameter is a measure of energy imparted to the object by the airbag after bringing the object to rest and plays a role in possible secondary injury such as whiplash.

Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained  
5 herein.